1,094,080

PATENT SPECIFICATION

DRAWINGS ATTACHED

1,094,080

Date of Application and filing Complete Specification: June 29, 1966.
No. 29105/66.
Application made in United States of America (No. 474880) on July 26, 1965.
Complete Specification Published: Dec 6, 1967.

Index at acceptance:—**B8** A(3D, 3E, 3H, 3J); **F1** R(3A3A, 3BX10)
Int. Cl.:—**B 65 g 65/30**

COMPLETE SPECIFICATION

Improvements in and relating to Hoppers

We, PULLMAN INCORPORATED, of 200 South Michigan, Chicago 3, Illinois, United States of America, organised and existing under the laws of the State of Delaware, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the mehod by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to an improved hopper of the kind used for the bulk storage or transport of material in particulate form, such as granular or pulverised materials, or n flud for such as lquds and solutions. Such hoppers are usually of inverted conical configuration, to facilitate emptying, and fluid,such as air, under pressure may be directed into an end of a discharge tube located in the bottom end portion of the hopper to promote outflow of the material.

Especially in the case of particulate materials there is a danger of the particles or grains adhering together in the region of the bottom end of the hopper causing clogging and hindering efficient emptying. Various proposals have been made for overcoming this difficulty but none has proved fully satisfactory, and it is the principal object of the present invention to provide a hopper equipped with simple, reliable and economical means for ensuring rapid and efficient emptying and for countering the tendency of the material to clog, adhere or jam in the downwardly-tapering bottom end portion of the hopper.

According to the invention there is provided a hopper for material in particulate or fluid form and having a downwardly tapering bottom end portion, there being located in said bottom end portion material discharge means including one end of a discharge tube having a venturi restriction and said discharge means being located in said hopper bottom end portion in a position to promote circulatory movement of said material in said bottom end portion prior to discharge, there being further provided in said end portion a vortex chamber above said discharge means, said vortex chamber being surrounded by an annular chamber communicable substantially tangentially thereof with a source of pressurised fluid so that said fluid will flow in a given direction around said annular chamber, said annular chamber being of diminishing cross-section in the direction of fluid flow and said annular chamber being in communication with said vortex chamber *via* a plurality of passageways disposed obliquely to the radial of said vortex chamber and extending generally in the direction of fluid flow around said annular chamber, the arrangement being such that pressurised fluid introduced into and flowing around said annular chamber will be directed through said passageways into said vortex chamber in a manner to create a whirlpool of said material in said vortex chamber above said discharge means.

At least some of said passageways may be inclined inwardly upwardly of the hopper from said annular chamber to said vortex chamber. Alternatively or in addition at least some of said passageways may be inclined inwardly downwardly of the hopper from said annular chamber to said vortex chamber.

There may be concentrically interposed between said annular and vortex chambers a substantially circular annular member having a plurality of passageways each opening at the radially inner and radially outer peripheries of said member at its respective ends and each extending obliquely to the radial of said member.

Said member may comprise a pair of similar, substantially flat rings maintained in parallel, spaced relation by the interposition there-

[*Price*

between of a plurality of vanes each disposed obliquely to the radial of said rings and providing said passageways therebetween. Said rings may be oppositely tapered the one from its radially outer to its radially inner edge and the other from its radially inner to its radially outer edge, the rings being arranged so that their opposed surfaces are substantially parallel and oblique with respect to the axis of the member and the remote surfaces of said rings lying in parallel planes perpendicuar to the axis of the member.

Two similar said members may be arranged in superimposed, mutually inverted relation between said annular and vortex chambers so that one of said members provides inwardly upwardly inclined passageways and the other provides inwardly downwardly inclined passageways.

Said discharge means preferably comprises a nozzle communicable with a source of pressurised fluid located eccentrically in said bottom end portion in coaxial alignment with said discharge tube end portion, the latter being of diminishing internal cross-sectional area from the orifice thereof to form a venturi therein. Said nozzle preferably tapers toward the orifice thereof and extends into but is not contiguous with said discharge tube end portion whereby an annular, frusto-conical gap is provided between said nozzle and the interior of the discharge tube for the inflow into said discharge tube of said material.

Preferred embodiments of the invention will now be described with reference to the accompanying diagrammatic drawings, in which:—

Figure 1 is an elevational view, partly in section, of a tank for the bulk storage or transport of material in particulate or fluid form and embodying two hoppers in accordance with the invention,

Figure 2 is a sectional view of a bottom end portion of one of the hoppers taken along line 2—2 of Figure 1,

Figure 3 is an elevational view partly in section of the hopper bottom end portion illustrated in Figure 2,

Figure 4 is a sectional view taken along line 4—4 of Figure 3,

Figure 5 is a sectional view taken along line 5—5 of Figure 3,

Figure 6 is a view taken along line 6—6 of Figure 5,

Figure 7 is a view in isolation of an annular member illustrated in the assembled position in Figures 3, 5 and 6,

Figure 8 illustrates a modified form of the annular member shown in Figure 7,

Figure 9 is a sectional view taken along line 9—9 of Figure 8, and

Figure 10 is a sectional view similar to Figure 9, through two annular members similar to that illustrated in Figure 7 arranged in superimposed, mutually inverted relation.

Referring first to Figure 1 of the drawings there is shown a generally cylindrical storage or transport tank 2 for carrying in bulk particulate material such as pulverulents or granular solid-like material. The storage tank 2 comprises a cylindrical housing 4 provided with a plurality of spaced material inlets 6 in the top portion thereof. In the interior of the housing 4 are a plurality of inverted conical hoppers 8, their upper end portions being separated from one another by a dividing wall 10 and each communicating with a respective inlet opening 6. Particulate material 12 such as powder or grain is introduced into each hopper through its respective inlet 6. The bottom end portion 14 of each inverted conical hopper 8 continues to taper downwardly to terminate in an apex portion 16. It is seen that the apex portion 16 of each hopper bottom end portion 14 is in communication with conduit means 18 including a source of fluid under pressure in the form of an air compressor 20. The air leaving the compressor 20 is directed through a pipe 22 of the conduit means 18 and then through a pipe 24 provided with a control valve 25 into the upper portion of the housing 4 to provide a pressure head above the material 12 within each of the hoppers 8, the compressed air being allowed to pass into each of the hoppers by way of a small opening 27 (see arrows) provided in the wall 10. Air pressure is also directed from pipe 22 into pipe 26 which branches into a plurality of branch pipes 28 that are directed to each of the apex portions 16 of the hoppers 8. Each branch pipe 28 in turn divides into a branch pipe 30 and a branch pipe 32 which respectively introduce compressed air to lower and upper portions of the apex portion 16 of each hopper 8. Control valves 34 and 36 respectively control the introduction of compressed air through these branch pipes 30 and 32 and permit that air pressure may be completely cut off from the associated apex portion 16 or only partial flow may be permitted or full flow of the compressed air may occur air pressure in each branch pipe 30 and 32 being controllable independently of that in the other. Extending eccentrically into the bottom end portion 16 of each hopper 8 is one end of a discharge tube 38, the tubes 38 joining at the other of their respective ends a main discharge conduit 40 *via* which the material on being discharged from the hoppers may be directed to a material storage container (not shown), said conduit 40 having a control valve 40*a* which is adjustable between the off and full on positions.

As seen particularly in Figures 2—6, the apex portion 16 of each hopper 8 comprises a downwardly tapering frusto-conical portion

42 that is attached to bottom end portion 14 of the hopper as by welds 44 securing a horizontal flange 46 of portion 42 thereto. Flange 46 is releasably secured to a similar lower flange 48 by bolts 50 and attached by weldments 51 to the flange 48 is an annular chamber 52 which is U-shaped in cross-section (see Figure 6). Chamber 52 is in the form of a spiral housing with an inlet 53 extending generally tangentially and having a lower conically shaped reduced-diameter portion 54 formed integrally with a horizontal outwardly extending flange part 56 spaced from chamber 52. To flange 56 is releasably secured by bolts 60 a flange 62 on a downwardly tapered bottom portion 58. The sloping wall 64 of part 58 is closed by a bottom wall 66. The U-shaped extension 68 provided by the annular chamber 52 serves to locate and support an annular member 70 shown in Figure 7. The member 70 comprises a top annular wall 72 in the form of a substantially flat ring and a bottom annular wall 74 is provided by a similar ring, the two rings 72, 74 being maintained in parallel, vertically spaced relation by a plurality of upright vanes 76. These vanes 76 define with the rings a plurality of air passages 79 that communicate the annular chamber 52 with the interior 78 of the hopper bottom end portion inside the member 70, this circular area 78 being hereinafter referred to as the vortex chamber of the hopper bottom end portion.

As best seen in Figures 2, 5 and 6 the annular chamber 80 formed by the U-shaped annular member 52 and annular member 70 joins with the inlet conduit 32 at 84 through the provision of a substantially tangentially extending socket 53. Thus chamber 80 has an enlarged area 85 at the position of air entry and then progressively decreases in cross-section in the direction of air flow (as indicated by the arrows in Figure 5) around the member 70 to where it has an area 86 of minimum cross-section adjacent the air entry position 84.

The vertical vanes 76, as viewed in Figure 5, are orientated obliquely with respect to radial lines eminating from the centre of the vortex chamber 78, i.e. the centre of member 70, so that they lie almost tangentially of the periphery of circular chamber 78 and almost in the direction of air flow around chamber 80. Thus as compressed air circulates from the enlarged area 84 to the reduced area 86 of the annular chamber 80 it will be seen that progressively less air is introduced into successive passages 79 defined by adjacent pairs of vanes, 76, 76. This ensures a substantially equal velocity of air passing through each passageway 79 into the vortex chamber 78. The air introduced substantially tangentially and at substantially equal pressure around member 70 causes the development of a whirlpool of the material 12 within the vortex chamber 78. The whirlpool has a theoretically infinite velocity at the central or core portion C of the chamber 78 and approaches zero pressure at this eye C of the whirlpool. The whirlpool has an increasingly greater pressure and decreasing velocity toward the periphery of the vortex chamber 78. The swirling of the particulate material causes any adhesion of the packed particles or grains to be broken up and the separated particles drop through the whirlpool for discharge from the part 58 below the vortex chamber.

As best seen in Figures 2 and 4, one end 30*a* of branch pipe 30 extends through an opening in the wall of bottom part 58 of the hopper and is welded thereto as at 92. An end 94 of the discharge tube 38 also extends into part 58 through another opening in its wall 64, the end portions 30*a* and 94 being located eccentrically within the part 58 and in coaxial alignment. The interior of tube end 94 is formed with a Venturi restriction 104 and the interior diameter of tube end 94 progressively increases in both axial directions from the restriction 104 so that the tube end tapers inwardly as at 94*a*.

The end portion 30*a* of pipe 30 within the part 58 extends into but is not contiguous with the tube end 94 and the portion of pipe end 30*a* surrounded by tube portion 94 tapers to form a nozzle 96 the interior bore 106 of which is aligned with the restricted area 100 of the bore in tube end 94. The external taper of nozzle 96 is similar to the internal taper of the bore of tube end 94 and since the pipe and tube are coaxial and non-contiguous and the surface 98 of the nozzle is generally parallel with the surface 94*a* of the tube bore a generally frusto-conical, annular passage remains therebetween into which air and material 12 will be sucked from the interior of part 58 in the direction of the arrows of Figure 4, thereafter being blown through the restricted area 100 of the tube bore and along the discharge tube 38. The eccentric disposition of the nozzle and discharge tube end promotes circulation of the material in the bottom of the hopper below the vortex chamber 78.

This association between the tapered nozzle 96 and the tapered portion 94 of tube 38 adjacent the Venturi restriction 104 therein causes the air under pressure introduced from the nozzle 96 into the tapered portion 94 of the bore of tube 38 through constriction 104 to pass at a high velocity, sucking air and the material 12 in the hopper bottom 58 through the frusto-conical passage 98 into tube 38. This sucking of the material 12 into the interior of the discharge tube 38 further breaks up any remaining clogging of the material which has passed through the vortex chamber.

Figures 8 and 9 illustrate a modification of the annular member 70 of Figure 7 in the

form of an annular member 116. The floor 112 and roof 114 of each passageway in the member 116 are parallel to one another but are oblique relative to the axis of the member, rather than lying in planes perpendicular thereto as do the remote surfaces of the member 116. One passageway 120 is directed inwardly upwardly of the member 116 while the adjacent passage 122 is directed inwardly downwardly and so on in alternate sequence around the periphery of the member 116. This causes compressed air to be directed through one passageway 120 upwardly of the hopper and through the adjacent passageway 122 downwardly of the hopper. This results in a greater vertical area of the material 12 being exposed to the compressed air passing through the passageways.

Figure 10 shows a further modification where two substantially identical annular members 116A and 116B, each constructed similarly to the member 70 of Figure 7, are provided in superimposed, mutually inverted relation to surround the vortex chamber 78. The rings which form the top and bottom of each member 116A or 116B are tapered in opposite directions radially of the member and arranged so that although the nearer surfaces 126 and 128 or 130 and 132 are parallel, (similarly to the remote surfaces of the rings which lie in parallel planes perpendicular to the axis of the member), they lie in planes oblique with respect to the axis of the member with the result that the passageways formed between the tapered rings and the vanes 120A or 120B are directed either inwardly upwardly of the member, as in the case of all the passageways of member 116A, or inwardly downwardly, as in the case of all the passageways of member 116B.

Thus it will be seen that when compressed air is admitted into the top of the housing 4 to exert an overhead downward force on the material 12 in each hopper 8 while concurrently air is forced through the annular member 70, 116 or 116A, 116B and through the Venturi restriction of the eccentrically disposed discharge tube 38 of each hopper, the entire bulk of the material 12 in each hopper is subjected to a downward feeding air pressure and to air pressure breaking it up and discharging it.

It will be appreciated that the invention is not restricted to hoppers for particulate material but is applicable to hoppers for other fluids, such as liquids. The arrangement of the invention permits gravity or pressurised discharge of liquids from a hopper and by virtue of the geometry of the vortex chamber will permit a complete discharge of such liquids without having to remove the liquids from residual pockets found in conventionally constructed hoppers. Further, in the hopper of the invention there are no moving parts or aerating pads t become saturated with liquid.

WHAT WE CLAIM IS:—

1. A hopper for material in particulate or fluid form and having a downwardly tapering bottom end portion, there being located in said bottom end portion material discharge means including one end of a discharge tube having a Venturi restriction and said discharge means being located in said hopper bottom end portion in a position to promote circulatory movement of said material in said bottom end portion prior to discharge, there being further provided in said end portion a vortex chamber above said discharge means, said vortex chamber being surrounded by an annular chamber communicable substantially tangentially thereof with a source of pressurised fluid so that said fluid will flow in a given direction around said annular chamber, said annular chamber being of diminishing cross-section in the direction of fluid flow and said annular chamber being in communication with said vortex chamber *via* a plurality of passageways disposed obliquely to the radial of said vortex chamber and extending generally in the direction of fluid flow around said annular chamber, the arrangement being such that pressurised fluid introduced into and flowing around said annular chamber will be directed through said passageways into said vortex chamber in a manner to create a whirlpool of said material in said vortex chamber above said discharge means.

2. A hopper as claimed in claim 1, wherein at least some of said passageways are inclined inwardly upwardly of the hopper from said annular chamber to said vortex chamber.

3. A hopper as claimed in claim 1 or claim 2, wherein at least some of said passageways are inclined inwardly downwardly of the hopper from said annular chamber to said vortex chamber.

4. A hopper as claimed in any preceding claim, wherein there is concentrically interposed between said annular and vortex chambers a substantially circular annular member having a plurality of passageways each opening at the radially inner and radially outer peripheries of said member at its respective ends and each extending obliquely to the radial of said member.

5. A hopper as claimed in claim 4, wherein said member comprises a pair of similar, substantially flat rings maintained in parallel, spaced relation by the interposition therebetween of a plurality of vanes each disposed obliquely to the radial of said rings and providing said passageways therebetween.

6. A hopper as claimed in claim 5 as appendant to claim 2 or claim 3, wherein said rings are oppositely tapered the one from its radially outer to its radially inner edge and

the other from its radially inner to its radially outer edge, the rings being arranged so that their opposed surfaces are substantially parallel and oblique with respect to the axis of the member and the remote surfaces of said rings lying in parallel planes perpendicular to the axis of the member.

7. A hopper as claimed in claim 6 and comprising two similar said members arranged in superimposed, mutually inverted relation between said annular and vortex chambers so that one of said members provides inwardly upwardly inclined passageways and the other provides inwardly downwardly inclined passageways.

8. A hopper as claimed in any preceding claim, wherein said discharge means comprises a nozzle communicable with a source of pressurised fluid located eccentrically in said bottom end portion in coaxial alignment with said discharge tube end portion, the latter being of diminishing internal cross-sectional area from the orifice thereof to form a Venturi therein.

9. A hopper as claimed in claim 8, wherein said nozzle tapers toward the orifice thereof and extends into but is not contiguous with said discharge tube end portion whereby an annular, frusto-conical gap is provided between said nozzle and the interior of the discharge tube for the inflow into said discharge tube of said material.

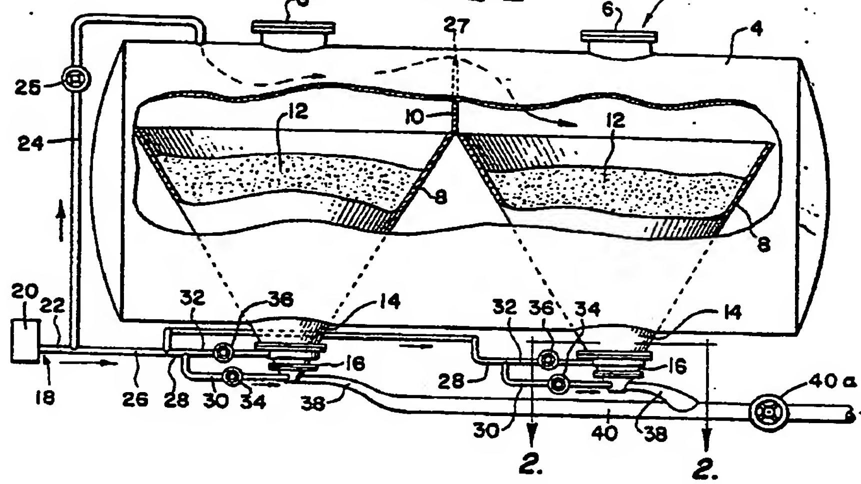
10. A hopper as claimed in any preceding claim, and comprising means for communicating the top end portion of the hopper above said material with a source of pressurised fluid.

11. A hopper substantially as hereinbefore described with reference to Figures 1 to 7 of the accompanying diagrammatic drawings or as modified by Figures 8 and 9 or Figure 10.

URQUHART-DYKES & LORD,
Chartered Patent Agents,
Columbia House, 69 Aldwych,
London, W.C.2, and
12 South Parade, Leeds, 1, Yorks.,
Agents for the Applicants.

Leamington Spa: Printed for Her Majesty's Stationery Office by the Courier Press.—1967.
Published at The Patent Office, 25, Southampton Buildings, London, W.C.2, from which copies may be obtained.

FIG. 1



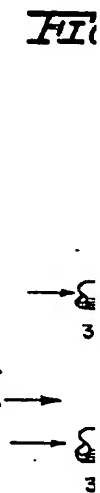
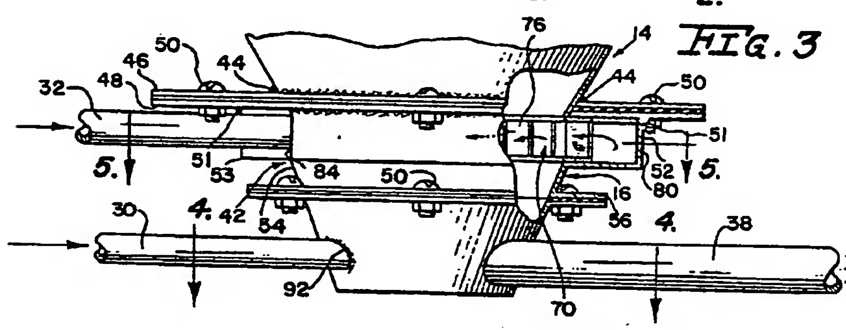


FIG. 3



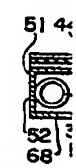


FIG. 7

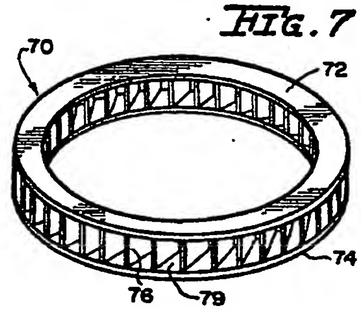


FIG. 10

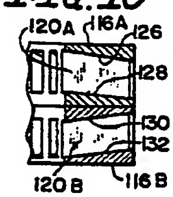
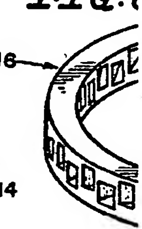


FIG.



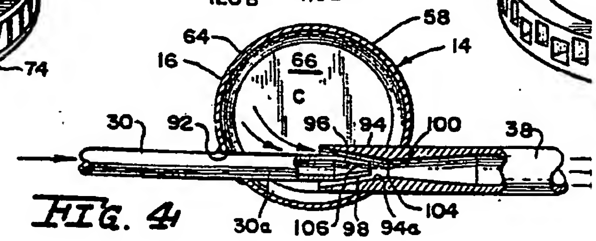


FIG. 4

1094080 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

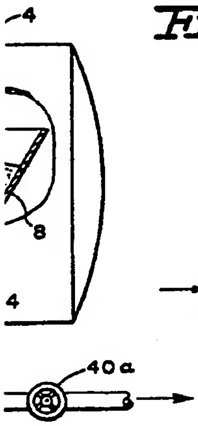


FIG. 2

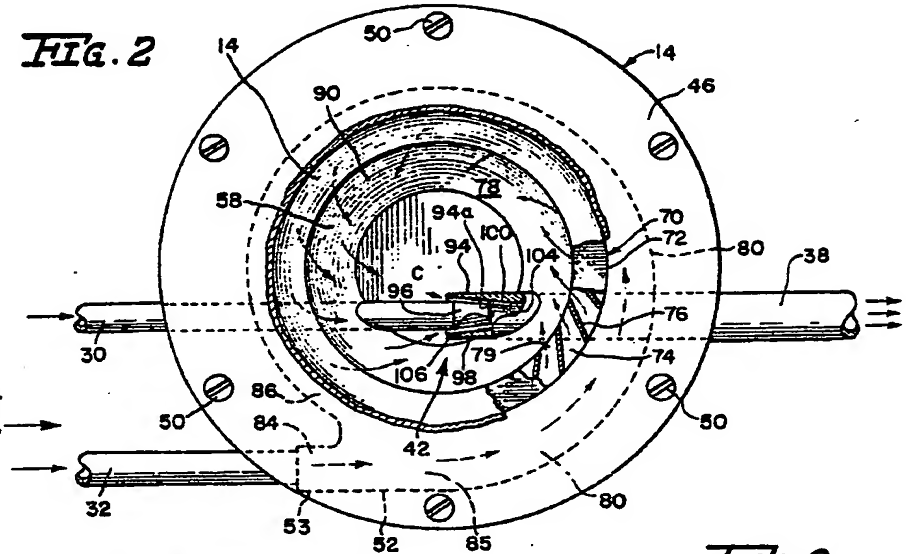


FIG. 3

FIG. 6

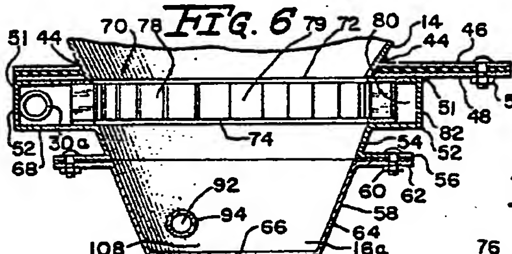


FIG. 9

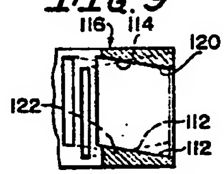


FIG. 8

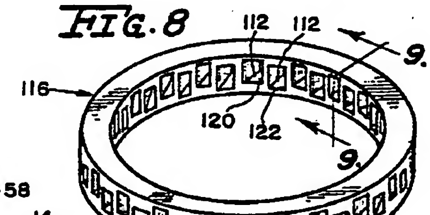
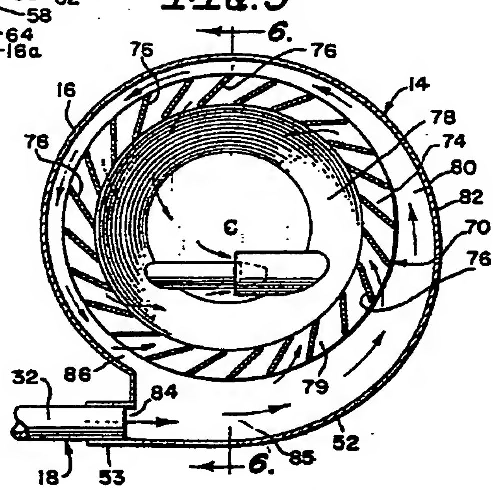
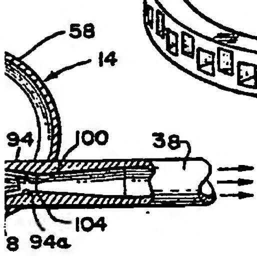


FIG. 5





1094080 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

FIG. 1

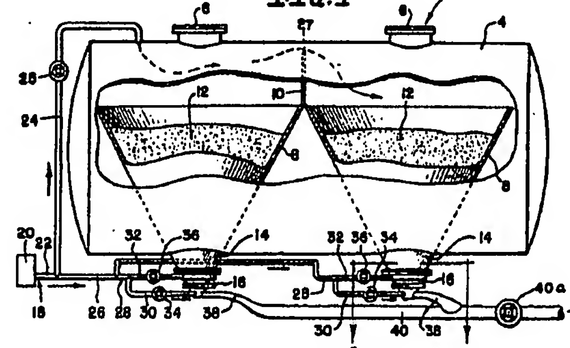


FIG. 2

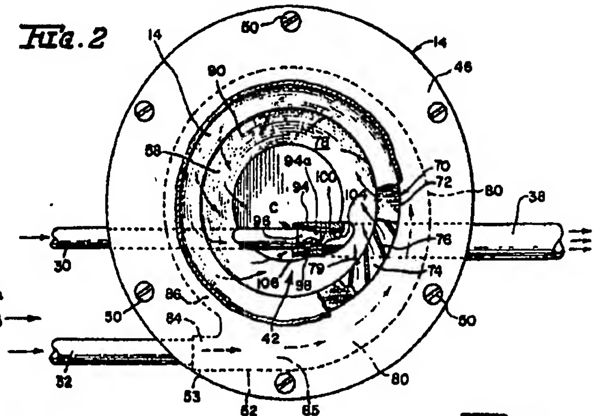


FIG. 3

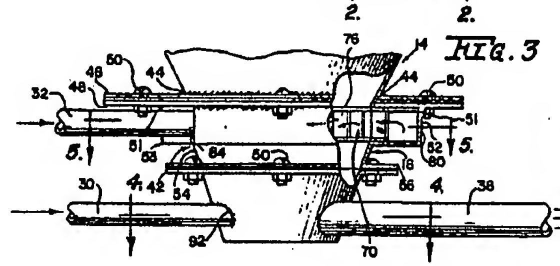


FIG. 6

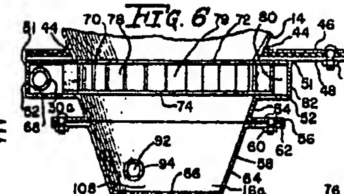


FIG. 9

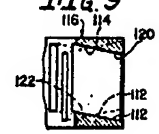


FIG. 5

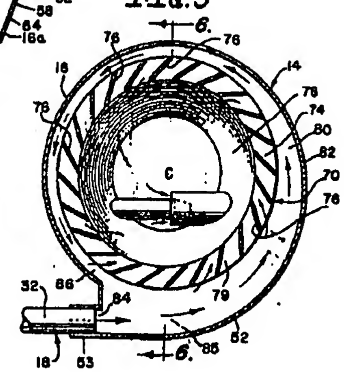


FIG. 7

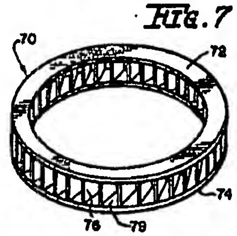


FIG. 10

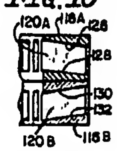
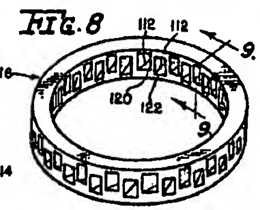


FIG. 8



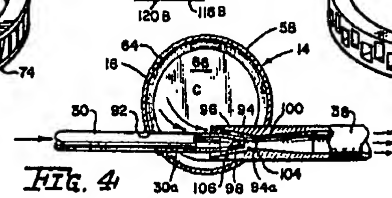


FIG. 4